Distribution and Diet of Southern Resident Killer Whales

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July 28, 2015

Program Review

An ESA listing requires two primary actions:

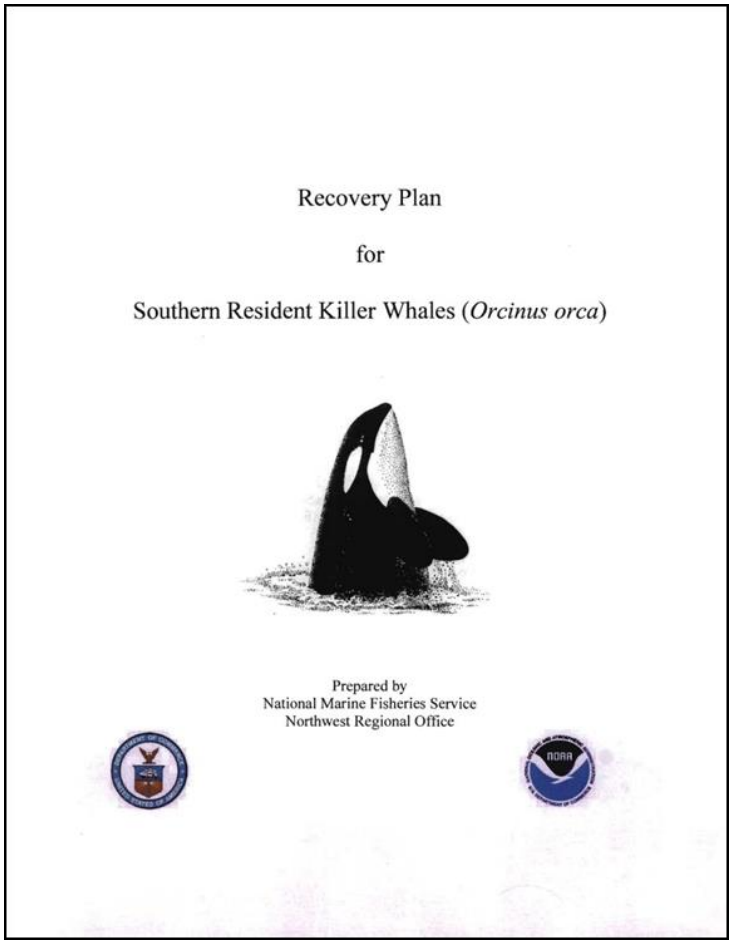
1) Development of a Recovery Plan to understand and address risk factors and data gaps limiting recovery of the population

Risk factors – Prey availability,

Vessel disturbance, Contaminant burdens

Winter distribution was ranked as the primary data gap

2) Critical Habitat designation

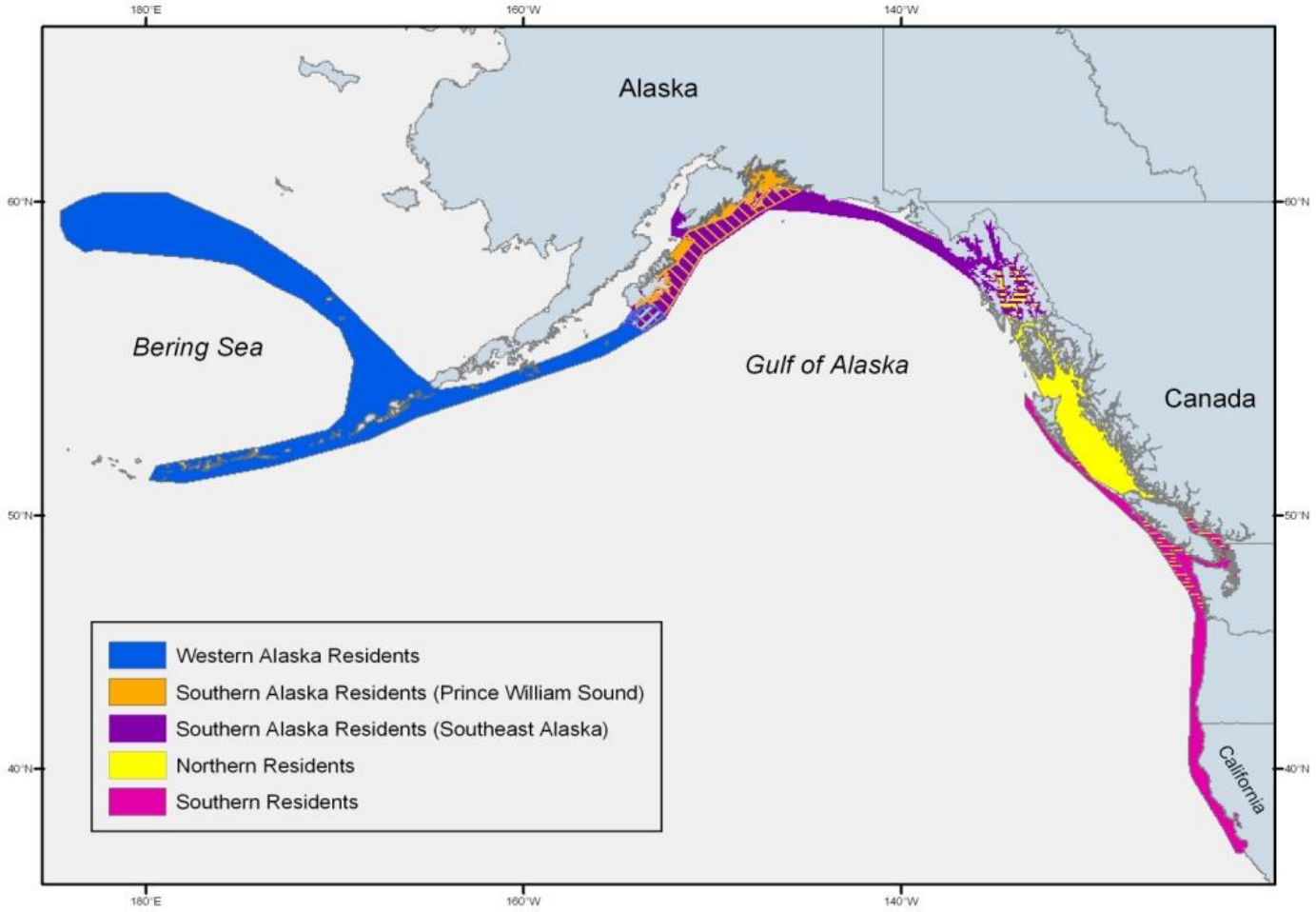

Recovery Plan

for

Southern Resident Killer Whales (*Orcinus orca*)

Prepared by
National Marine Fisheries Service
Northwest Regional Office

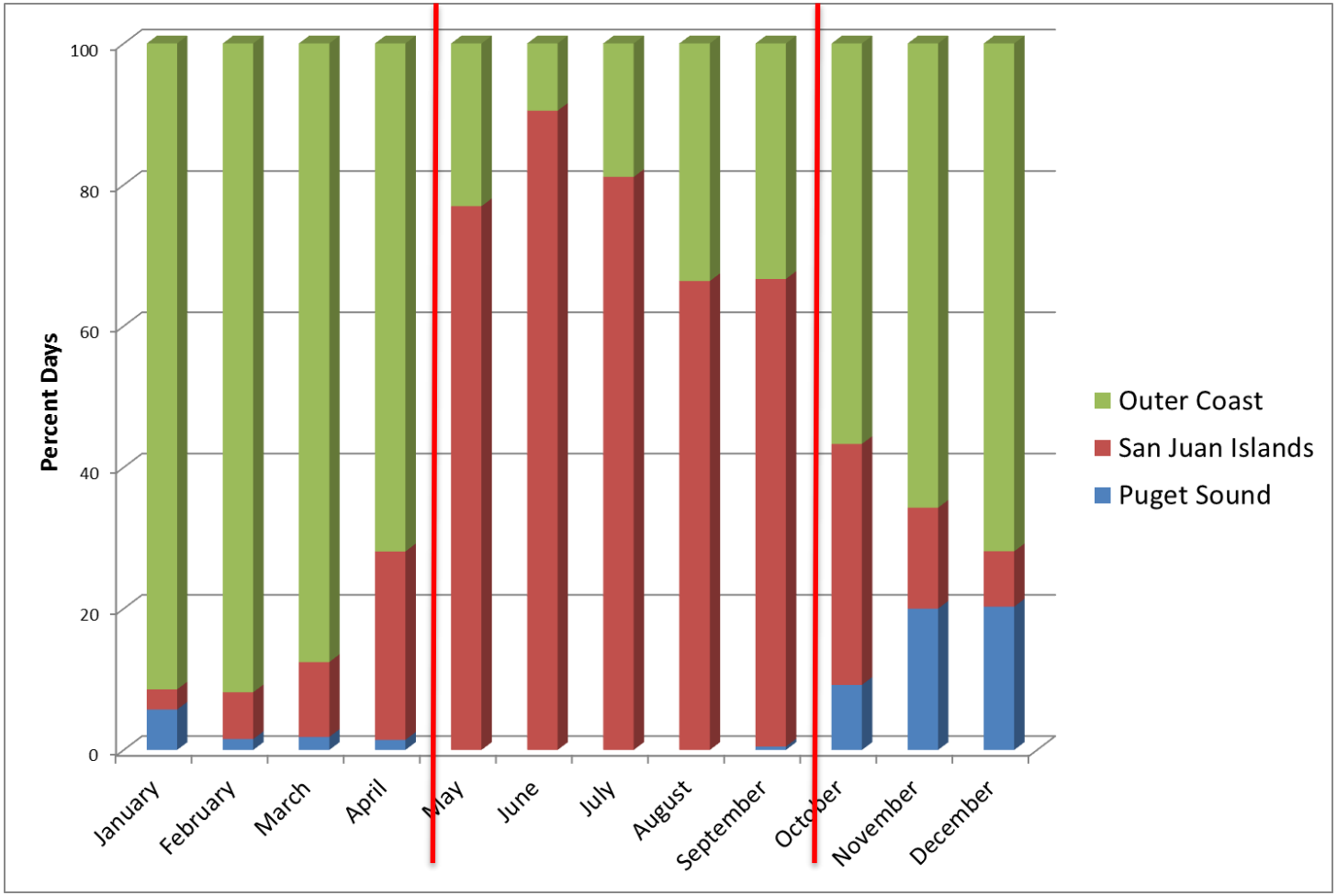
Where do SRKWs occur?



Approximate ranges for “Resident” eco-type killer whales in the eastern North Pacific

Where do SRKWs occur seasonally?

Percentage of time Southern resident killer whale pods were present in three main areas of their range

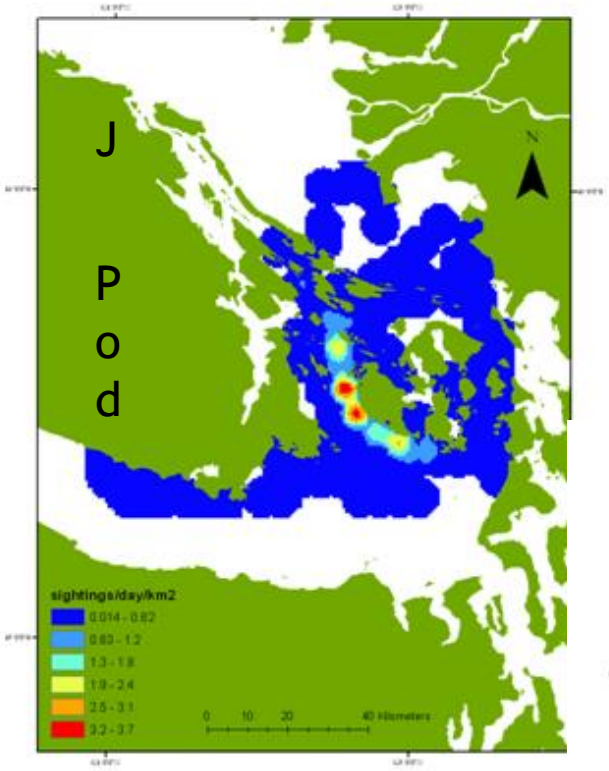


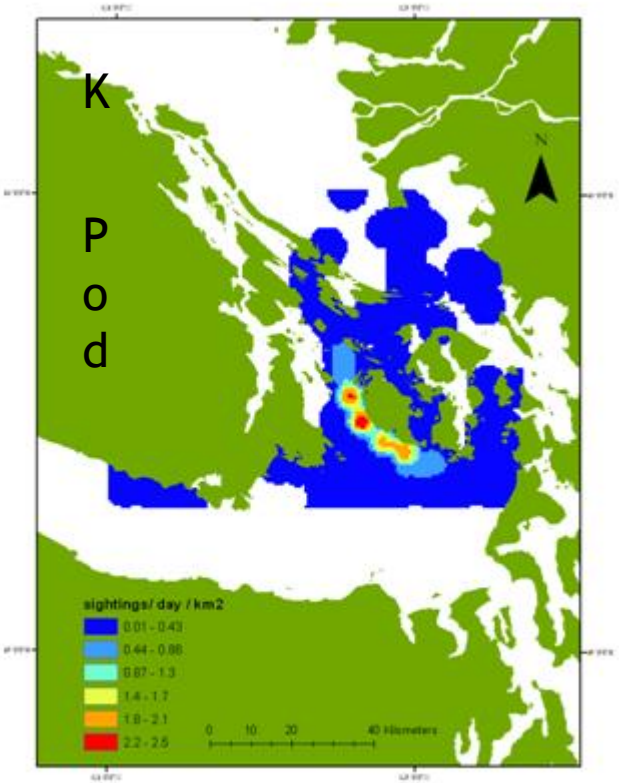
Three unique seasonal occurrence patterns for SRKWs

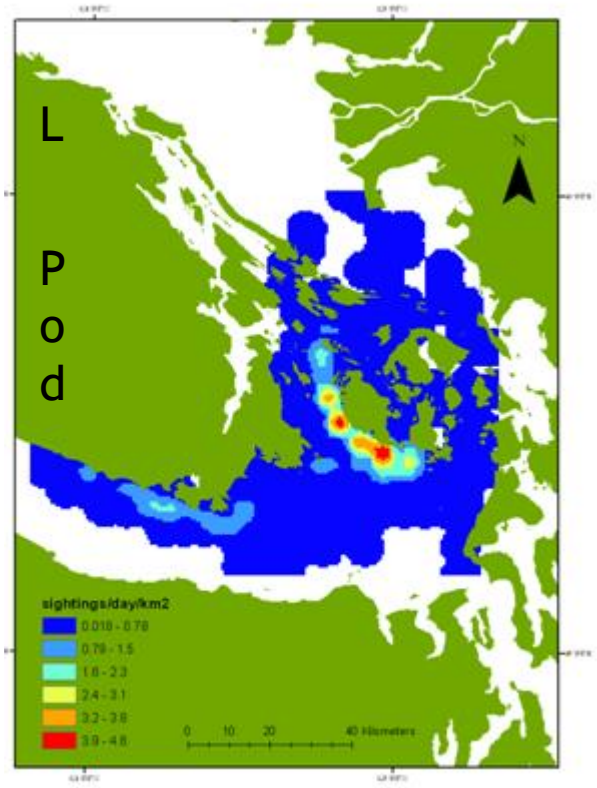
January – May **June – September** **October - December**

Sighting density in Summer Range by SRKW pod

Based on *thousands of sightings*, SRKWs primarily occur in the San Juan and Gulf Islands but highest density is off the southwest side of San Juan Island



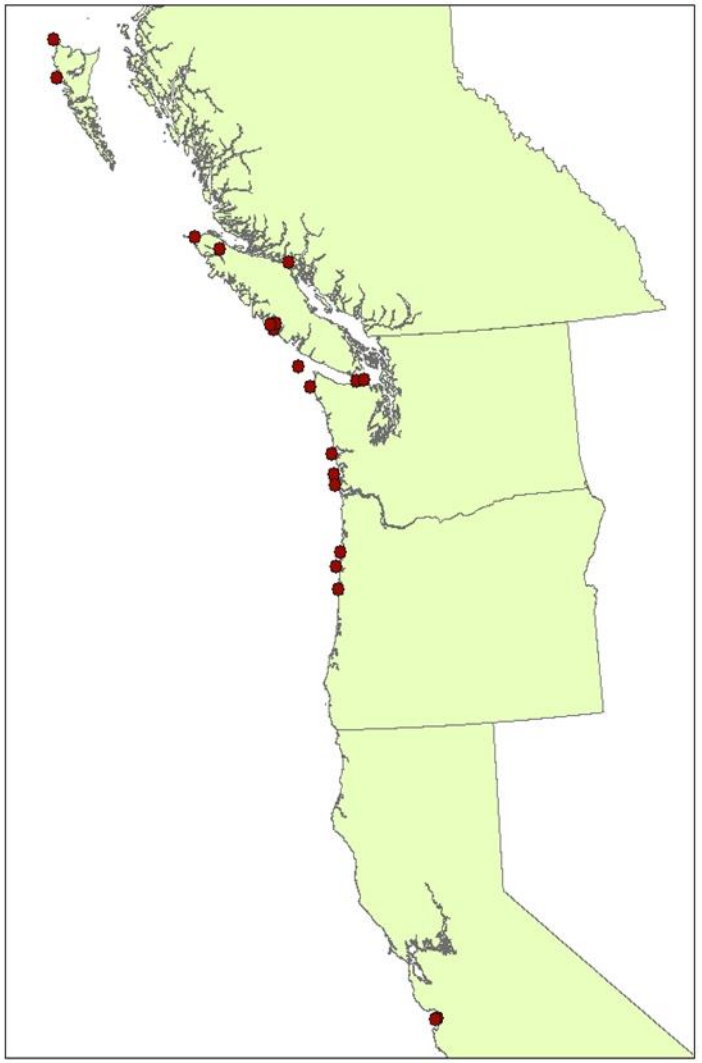




Hauser et al. 2007, Mar Ecol Prog Ser 351:301–310

What data were available on SRKW coastal range?

As of 2005 SRKW range was based on 19 sightings collected over 30 years



Off the U.S. west coast:

6 locations off Washington coast

3 locations off Oregon

2 locations off California

Approaches to accurately determine the coastal range of Southern Resident Killer Whales

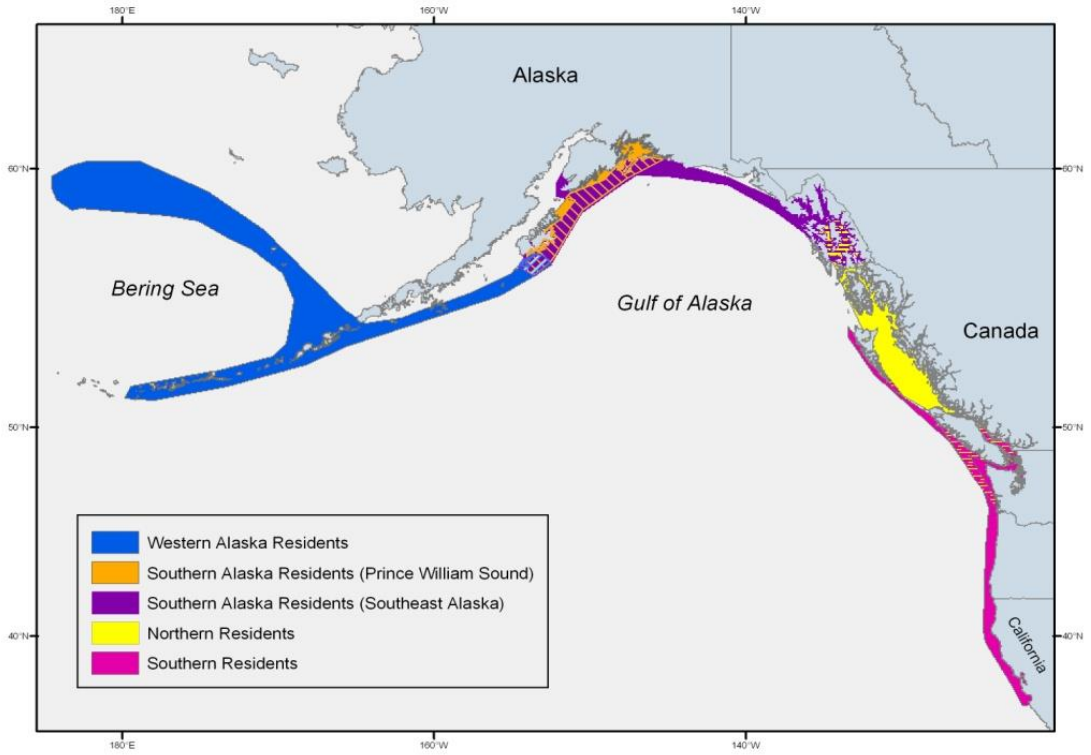
Methods identified in 2004 Research Planning workshop

1) Coastal sighting network

2) Passive acoustic recorders

3) Satellite tagging

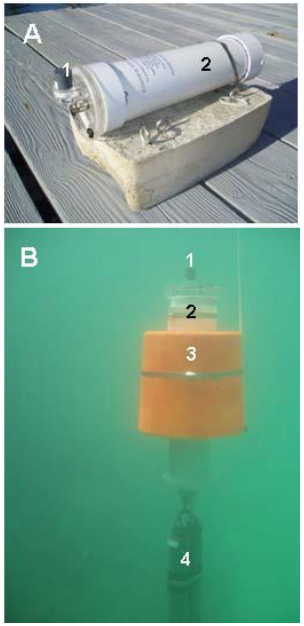
4) Ocean-class vessel cruises



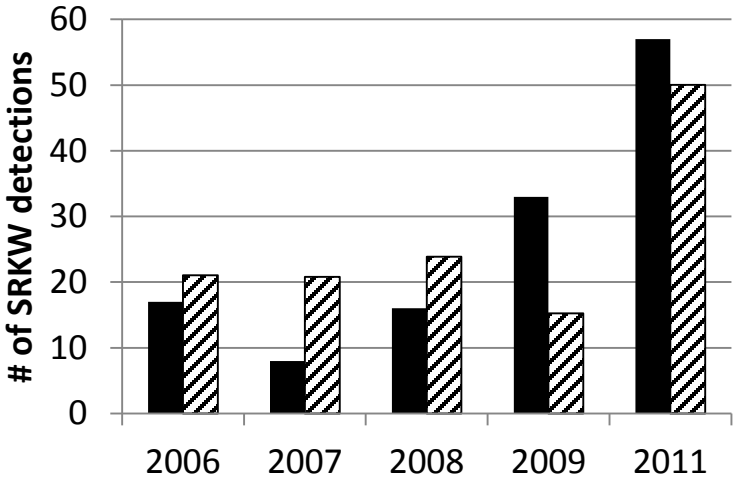
Autonomous Passive acoustic recorder deployments

- 7 recorder sites
- 2964 days monitored, 2006-2011
- 131 SRKW detections

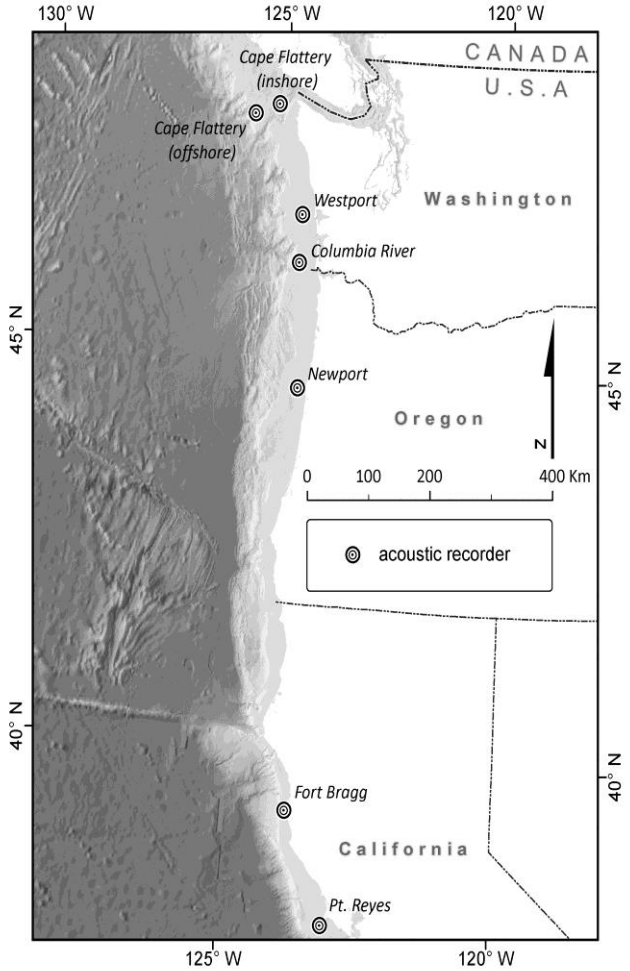
Jeff Nystuen (APL) - PAL



Marc Lammer's (OSI) Ecological Acoustic Recorder (EAR)



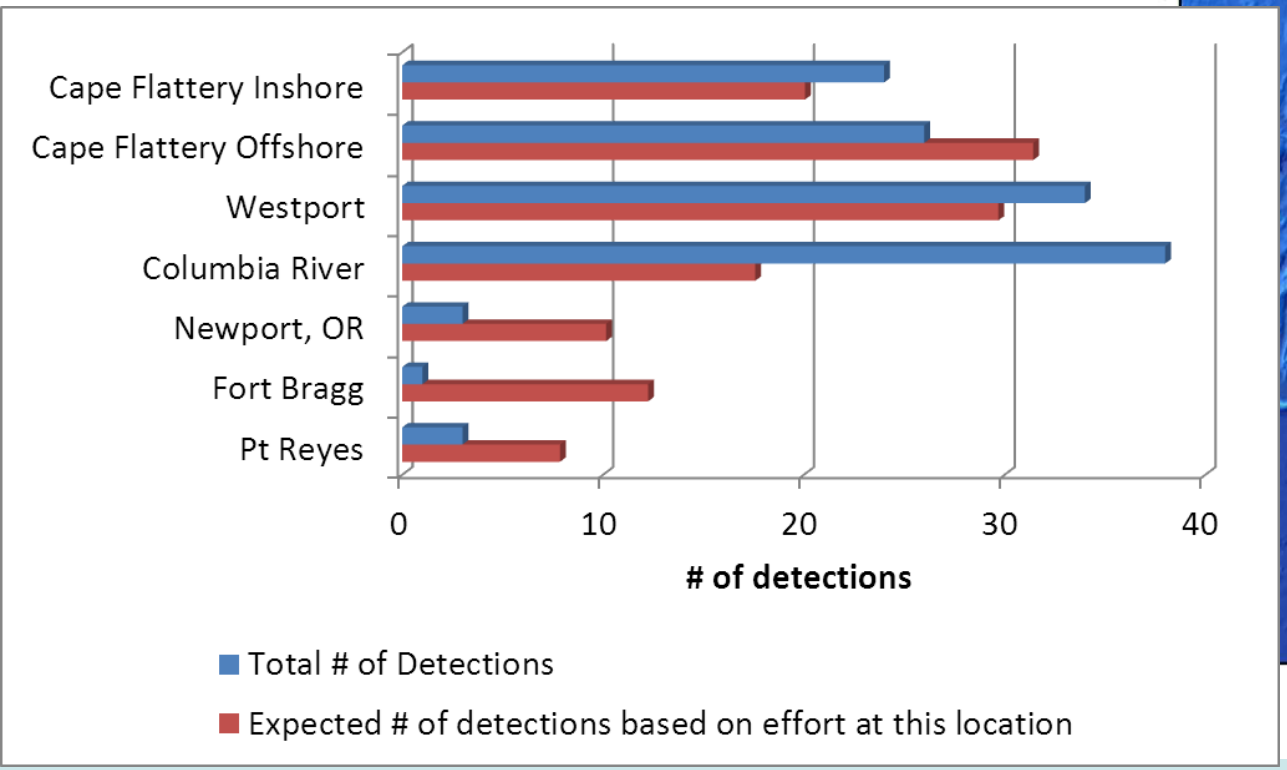
Annual observed number of SRKW detections (black bar) versus expected number of SRKW detections (diagonal bar)

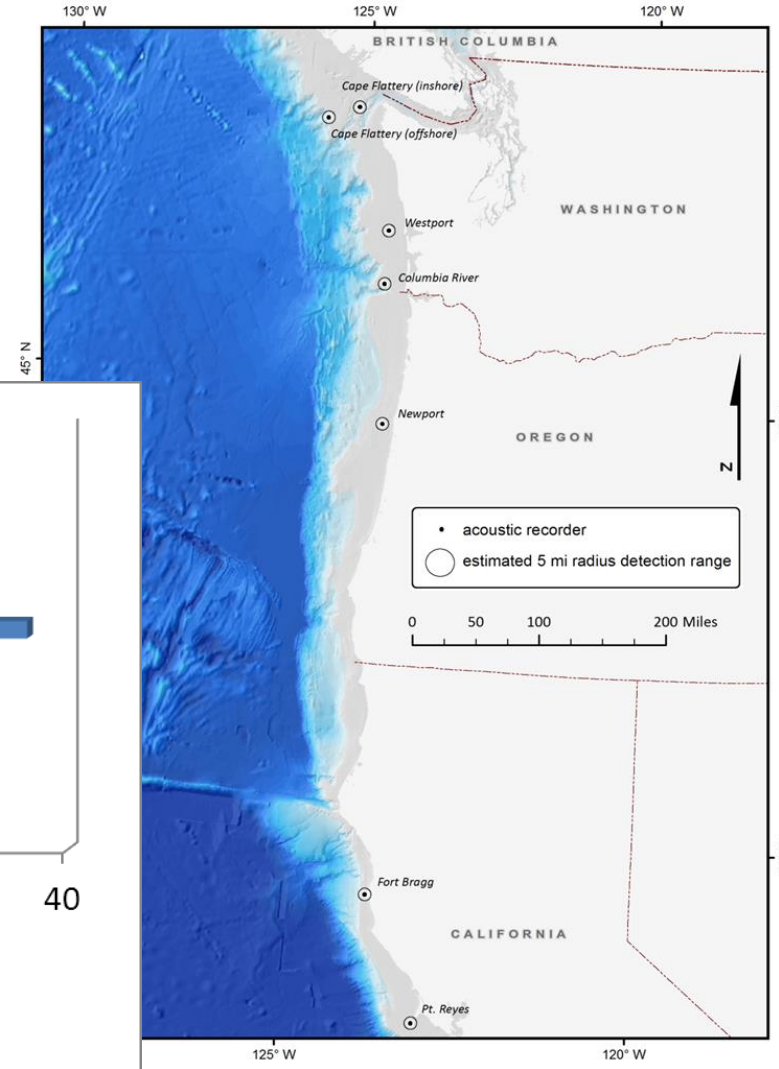


Hanson, M.B., C.K. Emmons, E.J. Ward, J.A. Nystuen, and M.O. Lammers. 2013. Assessing the coastal occurrence of endangered killer whales using autonomous passive acoustic recorders. J. Acoust. Soc. Am. 134 (5): 3486–3495.

Autonomous Passive acoustic recorder deployments

SRKWs were detected more often than expected off the Columbia River





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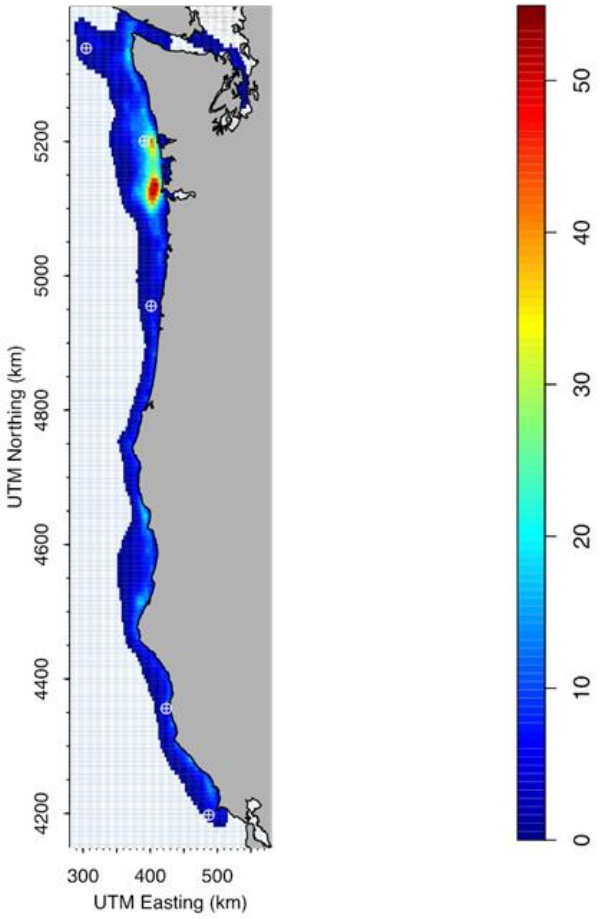
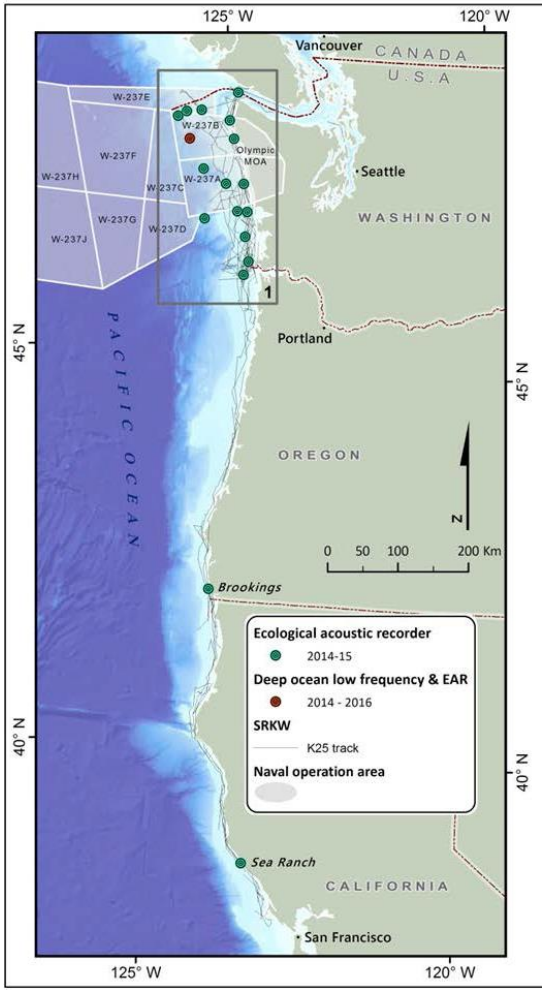
Autonomous Passive acoustic recorder deployments

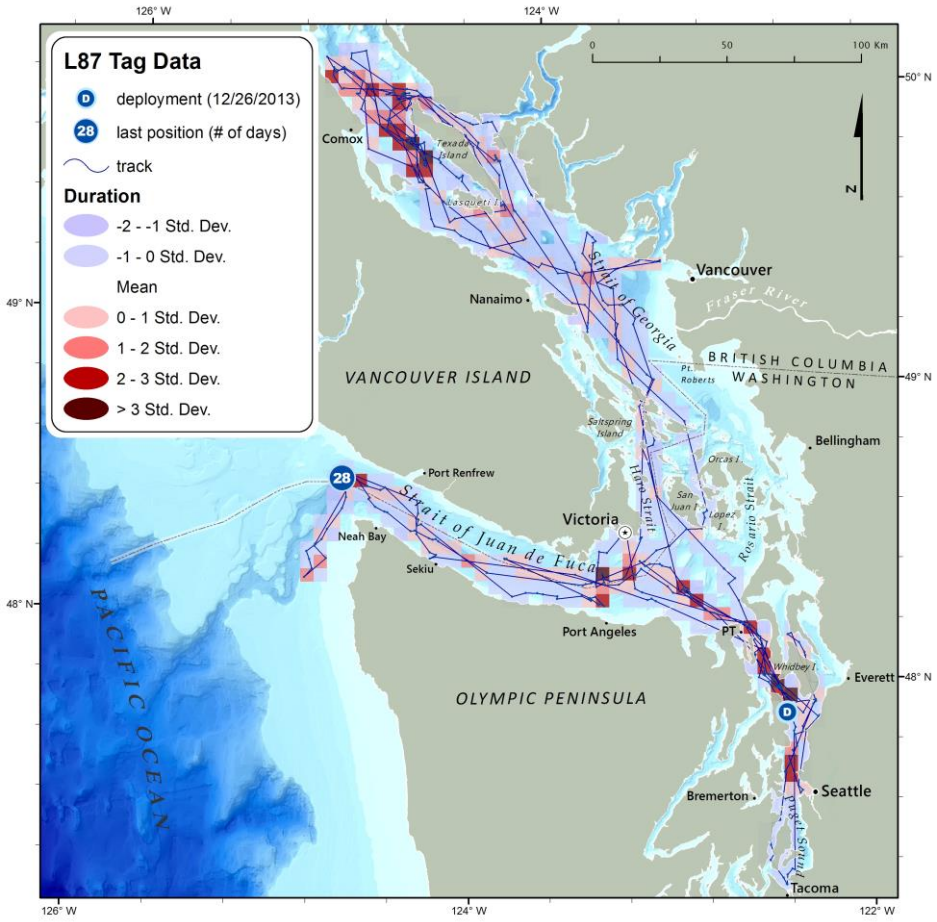


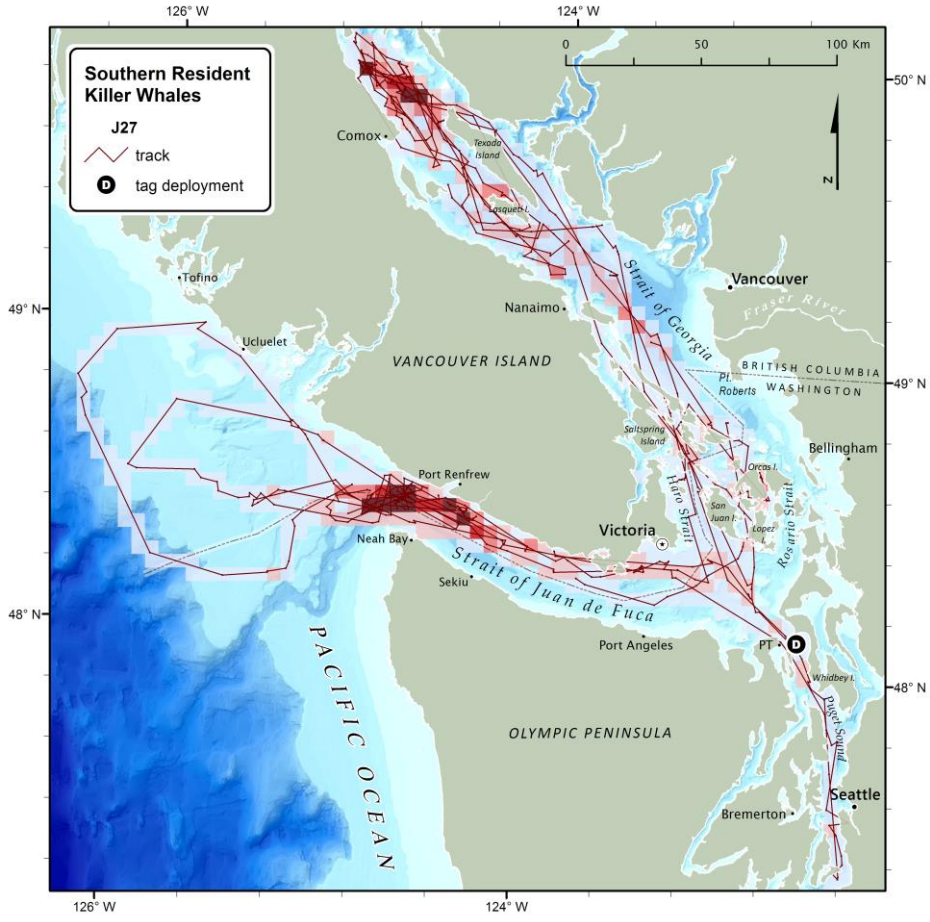
Dark red values in scale indicate occurrence 50x higher than expected by chance



State-space movement model of K25 satellite tag track was used to guide 2014 deployment of expanded array of acoustic recorders

Satellite tags provide data on SRKW winter movements – J pod, January –February 2014, 2015





Duration of occurrence density in 5x5 km grid cells relative to the mean shown in red

- J pod spent most of its time in, and moved extensively within the Salish Sea
- Limited use of coastal waters
- Northern Strait of Georgia was heavily used

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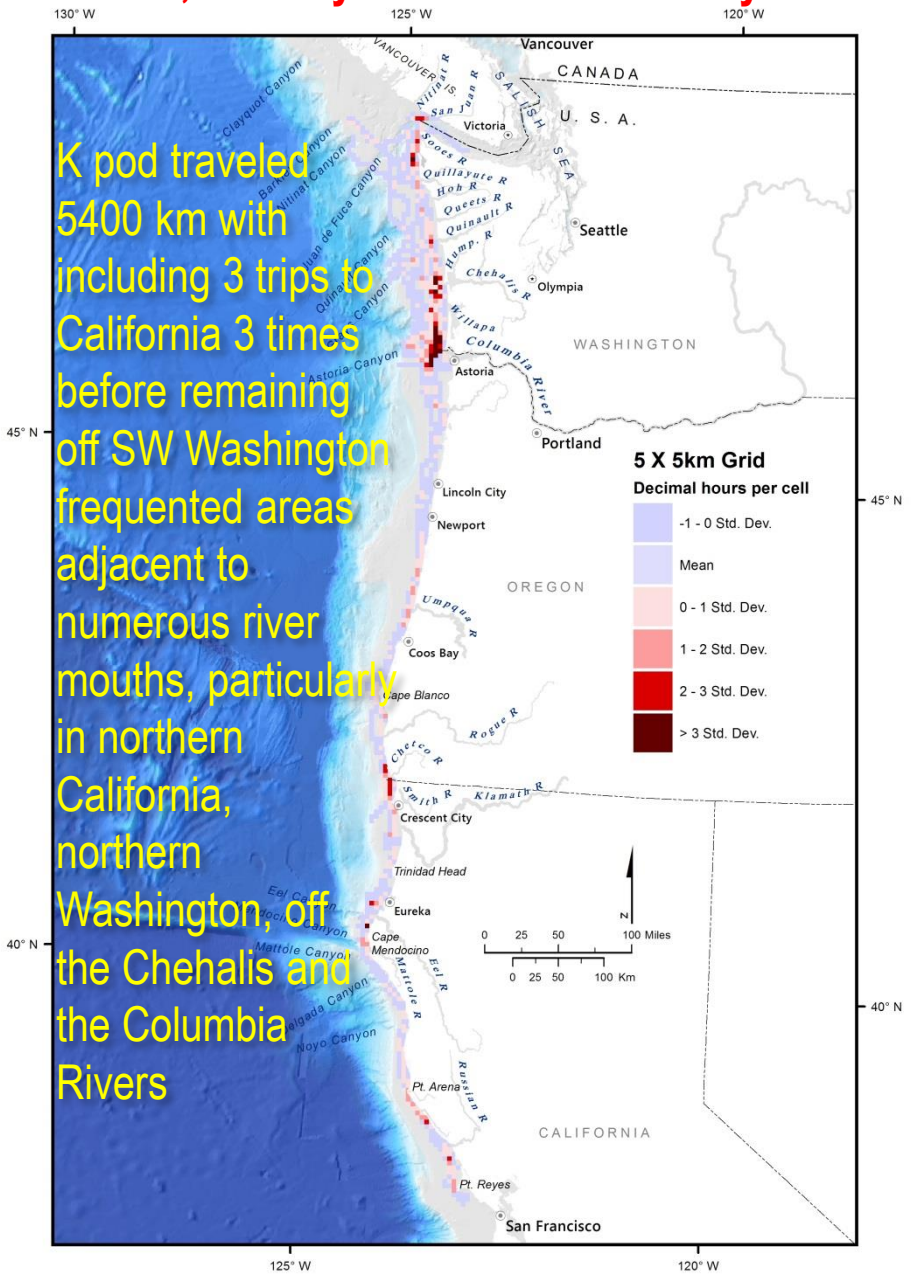
NWFSC, Cascadia Research unpubl. data

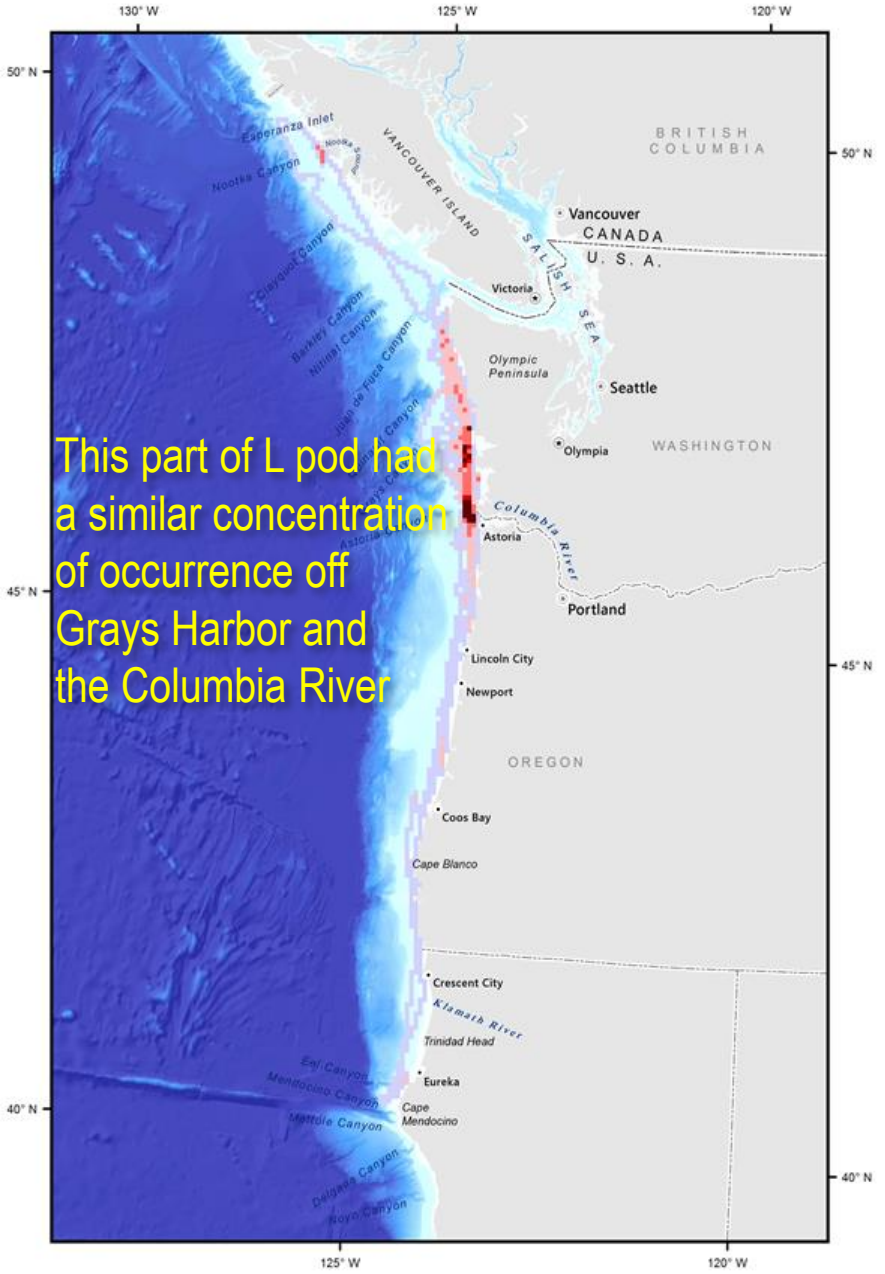
Satellite tags provide data on SRKW winter movements – K pod 2013, L pod 2015

K25, January - March 2013: 93 days



K pod traveled 5400 km with including 3 trips to California 3 times before remaining off SW Washington frequented areas adjacent to numerous river mouths, particularly in northern California, northern Washington, off the Chehalis and the Columbia Rivers

L84, February - May 2015: 96 days



This part of L pod had a similar concentration of occurrence off Grays Harbor and the Columbia River

What do SRKWs eat?

Previous approaches to SRKW prey relationships – availability/selection and their limitations

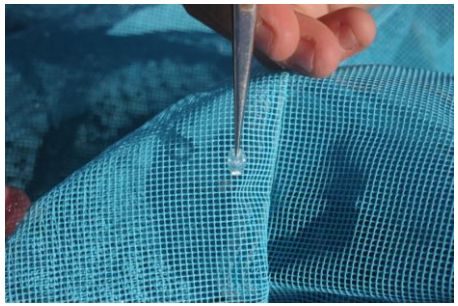
1) Anecdotal observations
   - very limited in number
   – but salmon were observed as a prey item

2) Whale presence/salmon catch data
   - inferential – guilt by association

3) Stomach contents/surface prey event sampling
   – small sample size

Photo by Astrid van Ginneken
Center for Whale Research

SRKW diet – 4 approaches



1) Predation event remains (scales, tissue)

2) Quantitative Fecal Prey DNA assessment

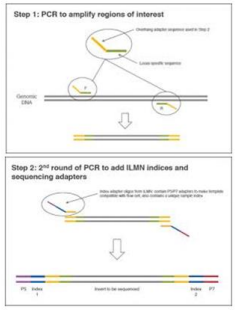
3) Stable Isotopes from biopsy

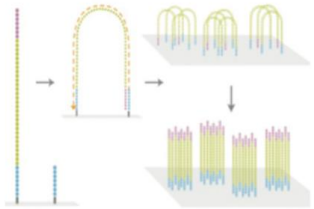
4) Contaminant ratio from biopsy

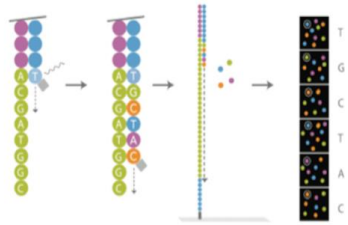
Quantitative Fecal Prey DNA assessment (Amplicon sequencing)

- Extract DNA from fecal samples (collected over a period of 8 years)

- Use next-generation sequencing (NGS) to generate thousands of sequences from individual pools of PCR products using the Illumina MiSeq platform.

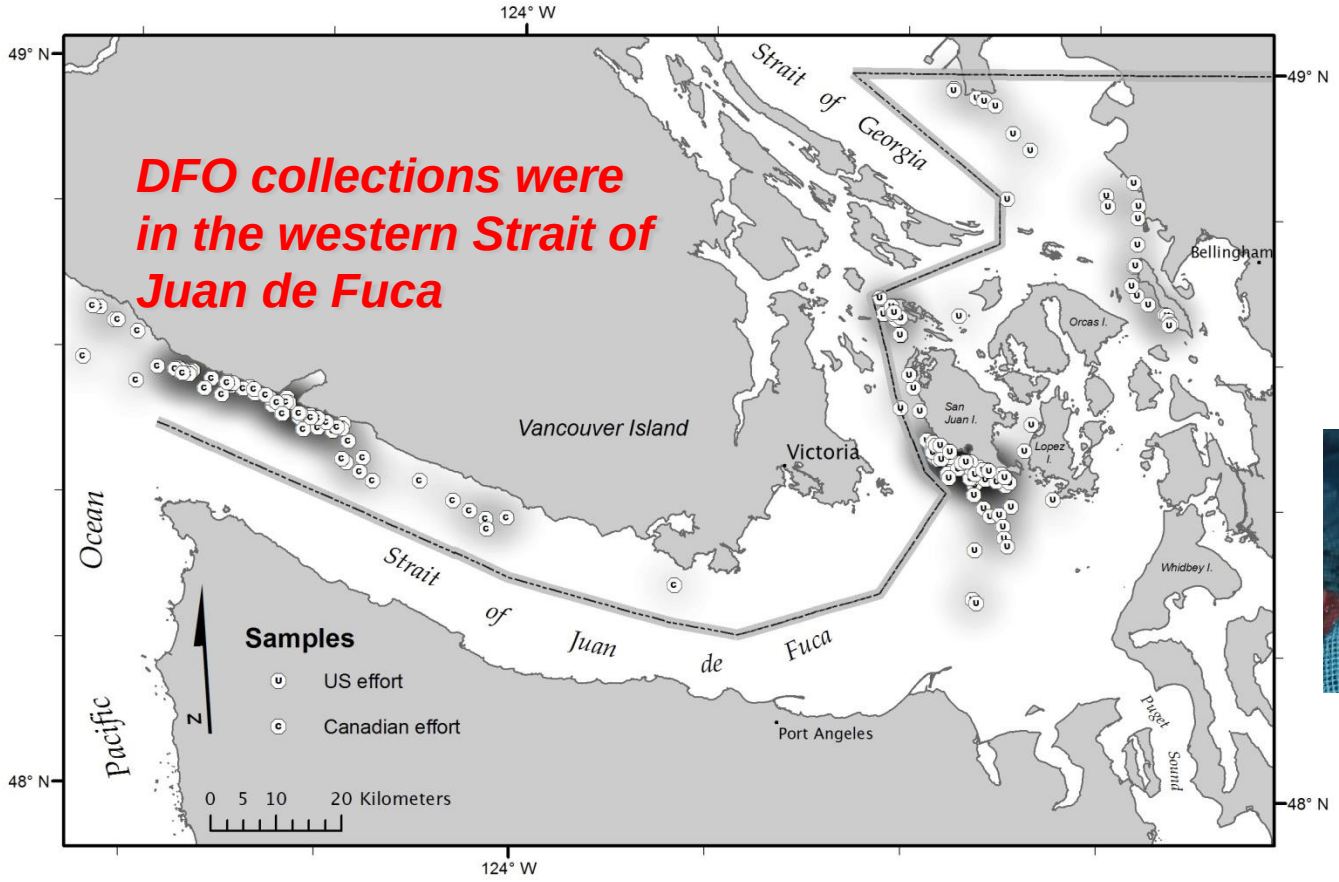






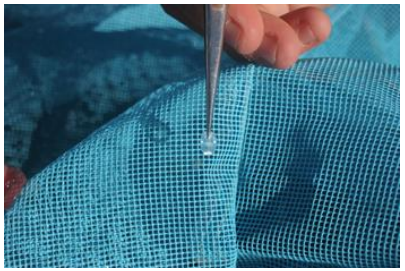
SRKW Focal Follow behavioral foraging study

Summer predation event locations in inland waters



DFO collections were in the western Strait of Juan de Fuca

A collaborative effort between DFO and U.S. researchers

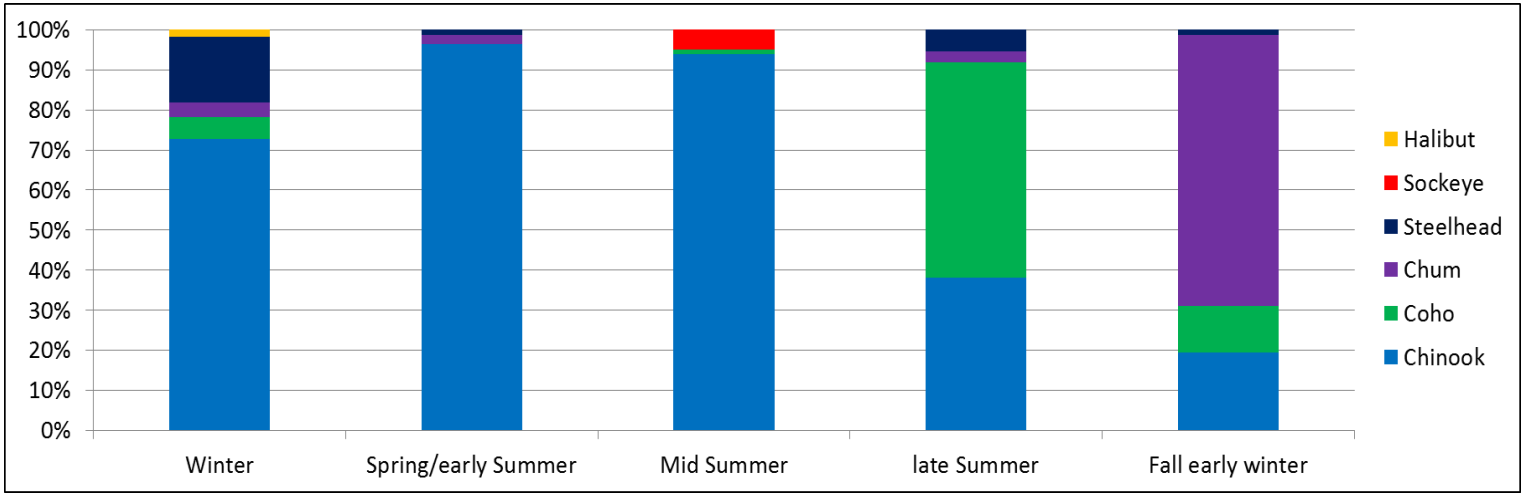


U.S. collection of predation events were located throughout the San Juan Islands but primarily in "core habitat" off the southwest side of the San Juan Islands.

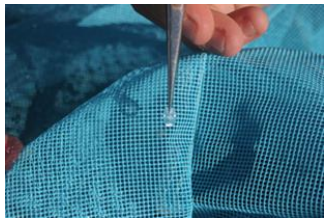
Hanson et al. 2010 Endangered Species Res

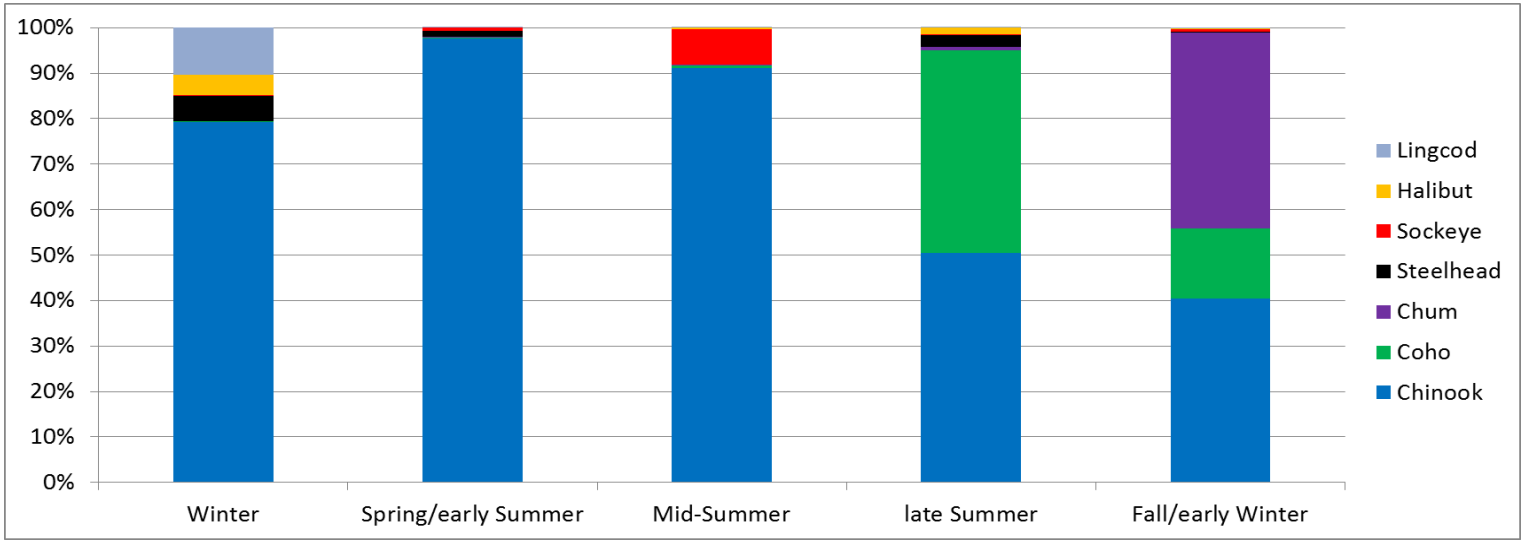
SRKW Diet - Results

San Juan Islands/Juan de Fuca | Puget Sound | Coastal waters



Prey remains





Fecal DNA

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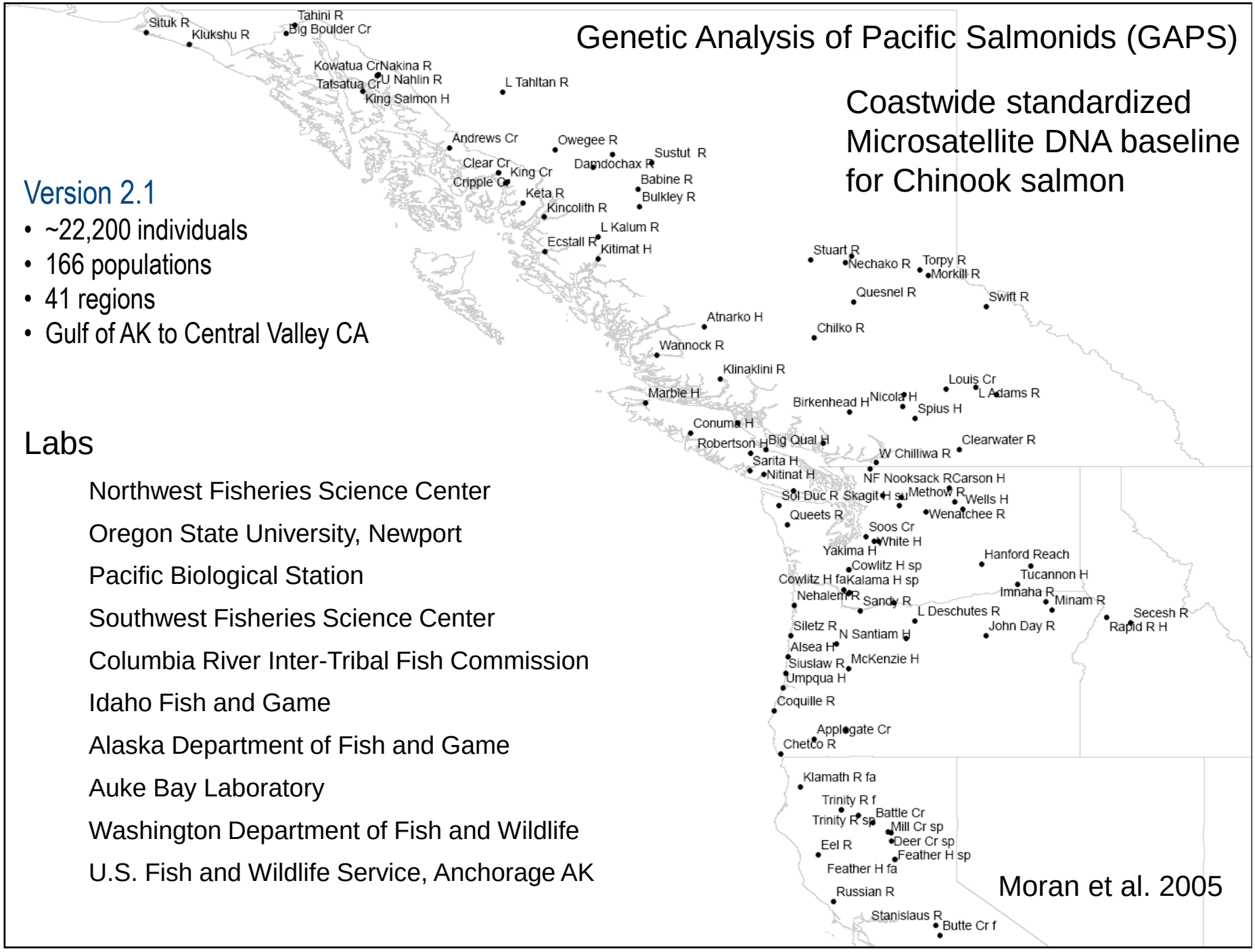
Hanson et al. 2010 Endangered Species Res. and NWFSC unpubl. data

Genetic Analysis of Pacific Salmonids (GAPS)

Coastwide standardized Microsatellite DNA baseline for Chinook salmon

Version 2.1

- ~22,200 individuals
- 166 populations
- 41 regions
- Gulf of AK to Central Valley CA



Labs

Northwest Fisheries Science Center

Oregon State University, Newport

Pacific Biological Station

Southwest Fisheries Science Center

Columbia River Inter-Tribal Fish Commission

Idaho Fish and Game

Alaska Department of Fish and Game

Auke Bay Laboratory

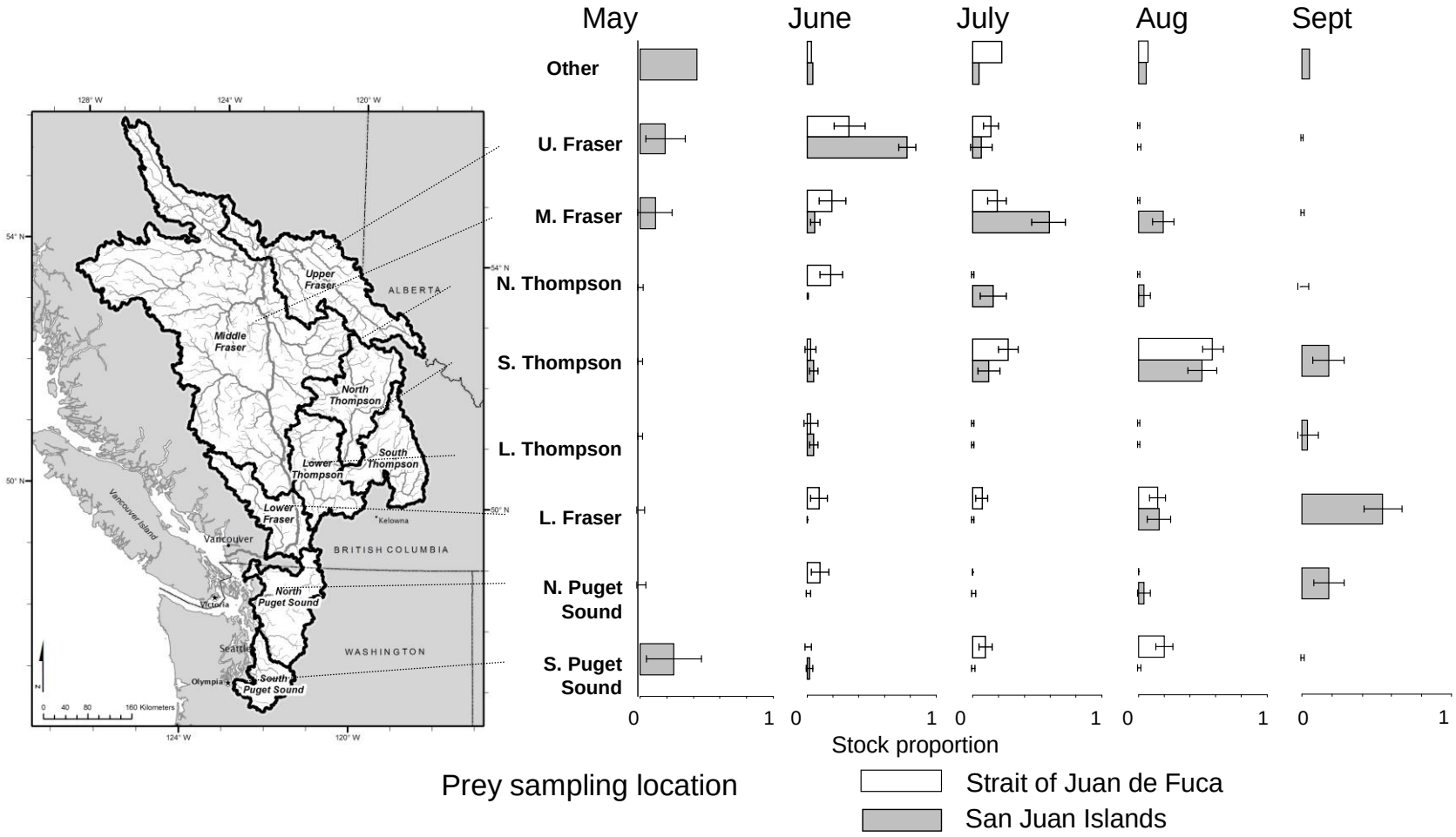
Washington Department of Fish and Wildlife

U.S. Fish and Wildlife Service, Anchorage AK

Moran et al. 2005

SRKW Summer Diet - Chinook stocks

Upper, Middle, and Lower Fraser, and South Thompson are seasonally important



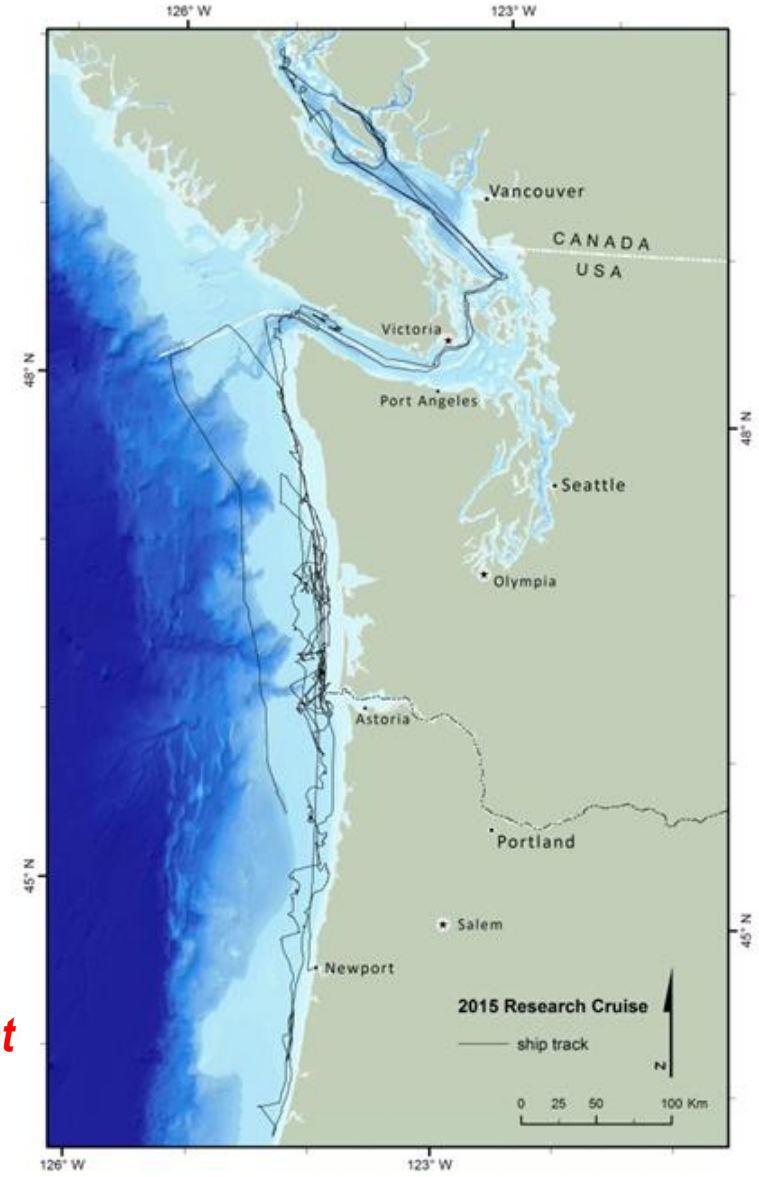
Hanson et al. 2010 Endangered Species Res

Ocean-class vessel cruises allows SRKW focal follows and ecosystem studies

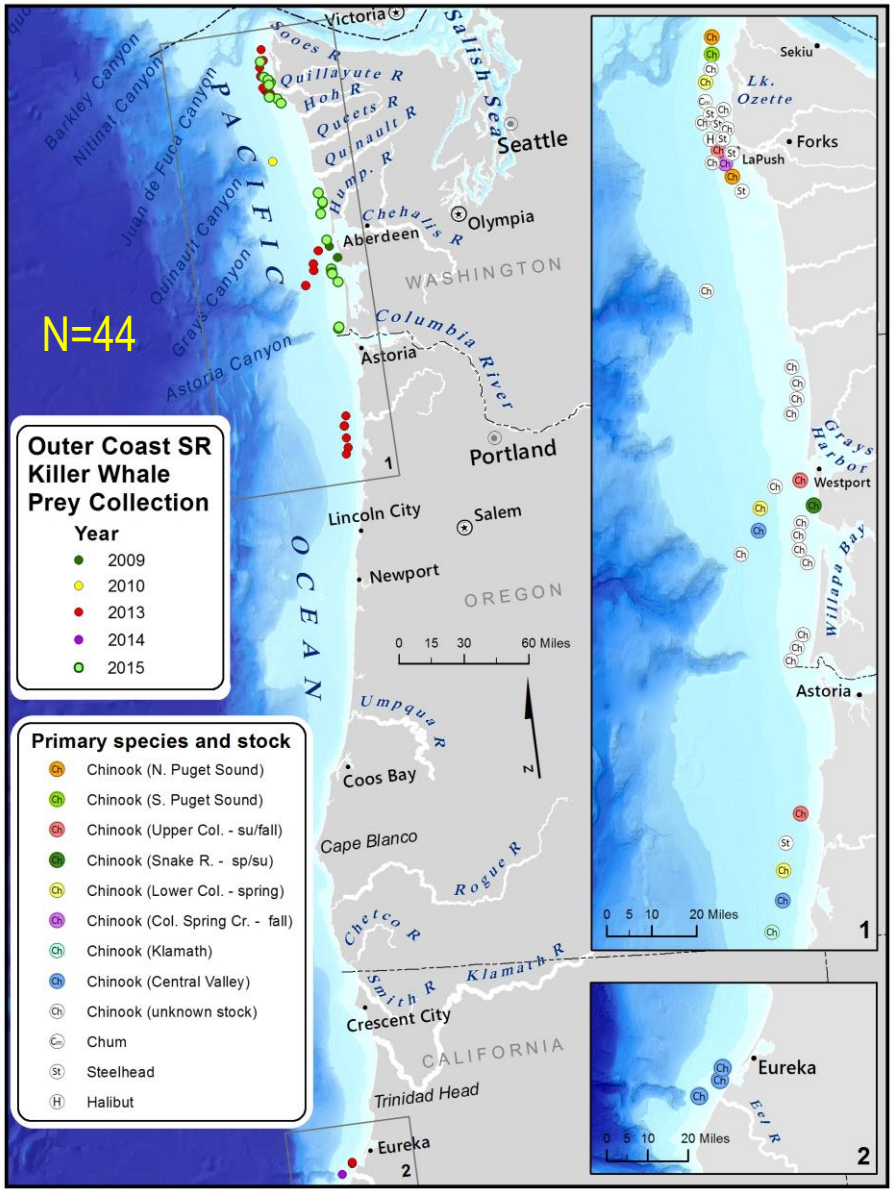
Eight 8-21 day winter/spring cruises on the McArthur II and Bell M. Shimada 2004-2015

1) Locate satellite tagged SRKW or tag SRKW
2) Coastal SRKW diet information
3) Acoustic recordings of SRKW
4) SRKW behavioral observations
5) Seabird counts
6) Zooplankton data
7) Oceanographic data
8) Echosounder data

These data will be important for assessing Critical Habitat

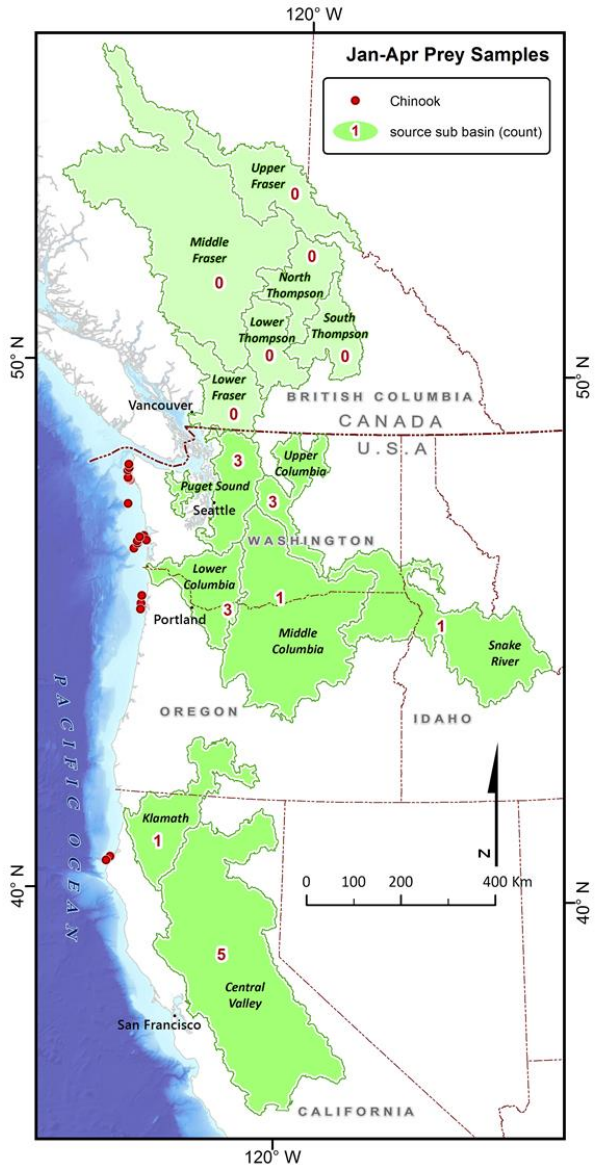


What Chinook stocks do SRKWs eat in winter?



Chinook Genetic Stock Identification included many U.S. west coast stocks:

- **Puget Sound**
- **Columbia River**
- **Klamath**
- **Central Valley**



Note that all Chinook came from relatively large drainages

Assessing Southern Resident Killer Whale diet from biopsy samples

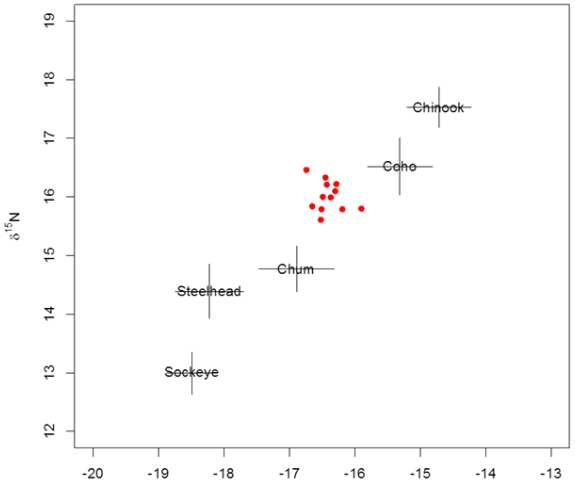
- Biopsies collected 2006-2015, N=75
- Mostly summer and fall, a few in winter

Can integrate information on diet over longer time frames than predation or fecal

- Stable Isotopes – ~previous two months – Can discern diet differences at the tropic level

- Diet is not exclusively Chinook

- Whales are likely eating prey that feed at a lower tropic level, i.e., chum, steelhead, or sockeye

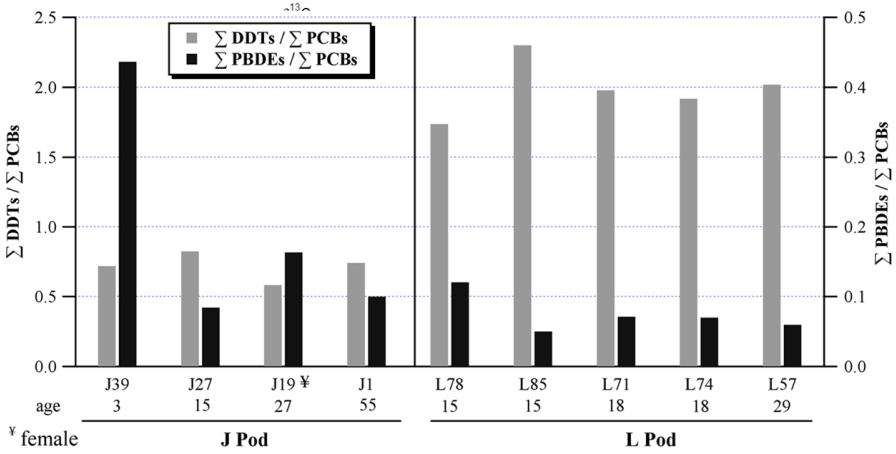


O'Neill and Ward, unpubl. data

- Contaminants

- Higher DDT/PCB ratios in L pod indicate that they foraging on prey that occur further south that J pod – consistent with California sightings of L and K pods

- Higher PBDE/PCB ratio in J pod suggests their prey are closer to an urban source



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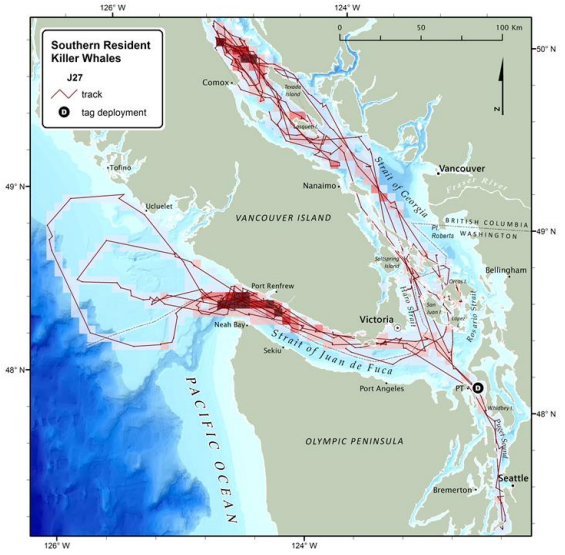
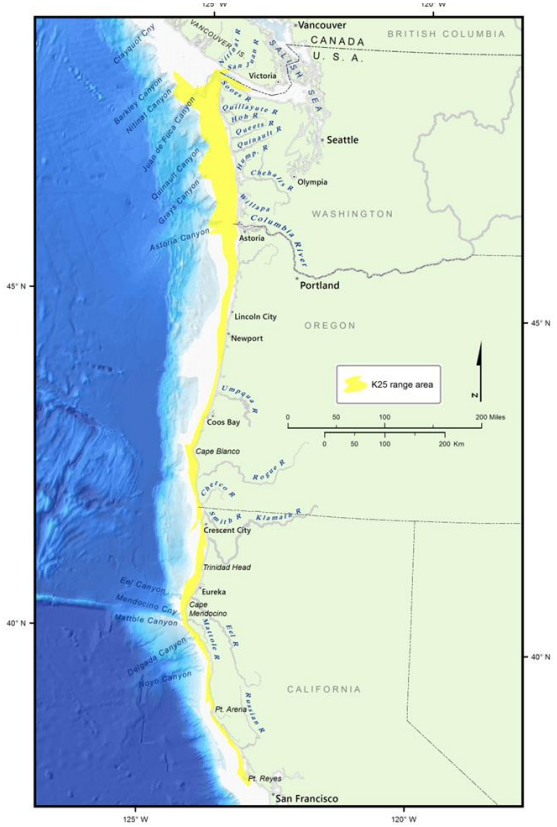
Krahn et al. 2009, Marine Pollution Bulletin 58: 1522–1529.

Summary – Winter Movements

- *Over the past 10 years we have developed and implemented new methods that has added significant new information to our understanding the winter distribution of SRKWs*
- *SRKW disperse by pod from their core summer range in the San Juan/southern Gulf Islands to other areas in the Salish Sea or the coastal waters of the U. S. and British Columbia*
- *J pod spent most of its time in, and moved extensively within the Salish Sea, particularly Northern Strait of Georgia with limited use of coastal waters*
- *K and L pods make extensive use of continental shelf waters from the entrance to the Strait of Juan de Fuca of northern California*
- *K and L pods spend a substantial portion of their time between Grays Harbor and the entrance to the Columbia River*





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Summary - Diet

- *Over the past 10 years we have enhanced, developed, and implemented new methods that has added significant new information to our understanding the diet of SRKWs*
- *Scales and tissues from Southern Resident Killer Whales predation events show a general preference for Chinook although other species may be seasonally or regionally important*
- *The Chinook in SRKW diet originate from a wide range of U.S. and Canadian west coast watersheds, particularly large drainages*
- *Feces integrates predation over a longer time period and shows a similar picture as predation but with a greater contribution of some other prey species*
- *Stable Isotopes from skin also shows evidence of a broader diet than Chinook over a multi-month period*
- *Contaminant ratios in blubber show K and Ls eating prey that remain in California – have been preying on these for years prior to sightings in that area*